RAY OPTICS & OPTICAL INSTRUMENTS

NEET Formula Sheet — Letsplaywithphysics.in

1. REFLECTION OF LIGHT

Plane Mirror

Laws of Reflection: $\angle i = \angle r$ (angle of incidence = angle of reflection)
Image formation: Virtual, erect, same size, distance = object distance

Spherical Mirrors (Concave & Convex)

Mirror equation: $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

Focal length: $f = \frac{R}{2}$ (where R = radius of curvature)

Magnification: $m = -\frac{v}{u} = \frac{h'}{h}$

Sign Convention (Mirror):

- Objects on same side as incident light: $u > 0$
- Real images: $v > 0$ (Concave mirror only)
- Virtual images: $v < 0$ (Convex & Concave)
- Concave mirror: $f > 0$; Convex: $f < 0$

2. REFRACTION OF LIGHT

Snell's Law

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

where n = refractive index, θ = angle from normal

Refractive Index

$n = \frac{c}{v}$ (speed of light in vacuum / speed in medium)

Relative R.I.: $n_{12} = \frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1}$

Critical Angle & Total Internal Reflection

$\sin\theta_c = \frac{n_2}{n_1}$ (for $n_1 > n_2$)

TIR occurs when: $\theta_i \geq \theta_c$ AND light travels from denser to rarer medium

Refraction at Spherical Surface

$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$

where u = object distance, v = image distance, R = radius of curvature

3. LENSES (THIN LENS)

Lens Equation

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

Power: $P = \frac{1}{f}$ (in diopters, f in meters)

Lens Maker's Formula

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

For liquid medium: $\frac{1}{f} = \left(\frac{n_{\text{lens}}}{n_{\text{liquid}}} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Magnification (Lens)

$$m = -\frac{v}{u} = \frac{h'}{h}$$

For thin lens: $m = \frac{f}{f-u}$

Sign Convention (Lens):

- Object real: $u > 0$
- Convex lens ($f > 0$): Converging
- Concave lens ($f < 0$): Diverging
- Real image: $v > 0$; Virtual: $v < 0$

4. COMBINATION OF LENSES

Lenses in Contact

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

Power: $P = P_1 + P_2$

Lenses Separated by Distance d

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

Equivalent power: $P = P_1 + P_2 - d \cdot P_1 P_2$

5. OPTICAL INSTRUMENTS

Simple Microscope (Magnifying Glass)

Magnification: $M = 1 + \frac{D}{f}$ (when final image at near point)

$M = \frac{D}{f}$ (when final image at infinity)

where $D = 25$ cm (least distance of distinct vision)

Compound Microscope

Magnification: $M = m_o \times m_e = \frac{v_o}{u_o} \times \left(1 + \frac{D}{f_e}\right)$

Tube length: $L = v_o + u_e$ (approximately)

m_o = magnification by objective, m_e = magnification by eyepiece

Telescope (Refracting)

Magnification: $M = -\frac{f_o}{f_e}$ (for final image at infinity)

Tube length: $L = f_o + f_e$

f_o = focal length of objective, f_e = focal length of eyepiece

Resolving Power

Microscope: $RP = \dfrac{1}{\text{min. distance}} \propto \dfrac{1}{\lambda}$

Telescope: Better with larger diameter objective

6. COMMON MISTAKES IN RAY OPTICS

Common Mistake

1. **Sign Convention Confusion:** Always check whether f and R are positive or negative. For mirrors: $f(+)$ = concave, $f(-)$ = convex.
2. **TIR Condition:** TIR only occurs when light goes from *denser to rarer*. $\theta_i \geq \theta_c$ is necessary.
3. **Lens Maker's Formula:** Remember signs of R_1 and R_2 carefully. $R(+)$ if center is on light exit side.
4. **Magnification:** For real images, m is always negative. Virtual images have $m > 0$.
5. **Compound Microscope:** Both objective & eyepiece contribute to magnification independently.

7. QUICK REVISION TABLE

Optical Element	Key Formula	Focal Length
Plane Mirror	$u + v = 2 \times \text{dist}$	∞
Concave Mirror	$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$	$f > 0$
Convex Mirror	$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$	$f < 0$
Convex Lens	$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$	$f > 0$
Concave Lens	$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$	$f < 0$
Prism	$\delta = (i + e) - A$	–
Snell's Law	$n_1 \sin\theta_1 = n_2 \sin\theta_2$	–

KEY RELATIONS AT A GLANCE:

- **Mirrors & Lenses:** Both follow $\dfrac{1}{f} = \dfrac{1}{u} + \dfrac{1}{v}$
- **Magnification:** $m = -\dfrac{v}{u}$ (same for mirror and lens)
- **Power of lens:** $P(\text{diopters}) = \dfrac{100}{f(\text{cm})}$
- **Refractive index:** Higher n means slower light speed
- **Critical angle:** $\sin\theta_c = \dfrac{1}{n}$ (for air-medium interface)